J Am Soc Nephrol 12: 2753–2758, 2001

Forecast of the Number of Patients with End-Stage Renal Disease in the United States to the Year 2010

JAY L. XUE,* JENNIE Z. MA,[†] THOMAS A. LOUIS,* and ALLAN J. COLLINS*
**United States Renal Data System, University of Minnesota, Minneapolis, Minnesota, and [†]United States Renal Data System, University of Tennessee, Memphis, Tennessee.*

Abstract. As the United States end-stage renal disease (ESRD) program enters the new millennium, the continued growth of the ESRD population poses a challenge for policy makers, health care providers, and financial planners. To assist in future planning for the ESRD program, the growth of patient numbers and Medicare costs was forecasted to the year 2010 by modeling of historical data from 1982 through 1997. A stepwise autoregressive method and exponential smoothing models were used. The forecasting models for ESRD patient numbers demonstrated mean errors of −0.03 to 1.03%, relative to the observed values. The model for Medicare payments demonstrated −0.12% mean error. The R^2 values for the forecasting models ranged from 99.09 to 99.98%. On the basis of trends in patient numbers, this forecast projects average annual growth of the ESRD populations of approximately 4.1% for new patients, 6.4% for long-term ESRD patients, 7.1% for dialysis patients, 6.1% for patients with functioning transplants, and 8.2% for patients on waiting lists for transplants, as well as 7.7% for Medicare expenditures. The numbers of patients with ESRD in 2010 are forecasted to be 129,200 ± 7742 (95% confidence limits) new patients, 651,330 ± 15,874 long-term ESRD patients, 520,240 ± 25,609 dialysis patients, 178,806 ± 4349 patients with functioning transplants, and 95,550 ± 5478 patients on waiting lists. The forecasted Medicare expenditures are projected to increase to \$28.3 ± 1.7 billion by 2010. These projections are subject to many factors that may alter the actual growth, compared with the historical patterns. They do, however, provide a basis for discussing the future growth of the ESRD program and how the ESRD community can meet the challenges ahead.

The growth in the end-stage renal disease (ESRD) program since its inception in 1972 has been a public health success, particularly because ESRD was a universally fatal disease before that time (1). The number of patients receiving treatment for ESRD in the United States increased from 158,332 to 323,159 in the past decade (2–4), whereas the number of new patients with ESRD increased from 45,127 in 1989 to 87,534 in 1998 (3,4). This growth in the ESRD population has substantial public policy implications, with annual Medicare patient costs of \$52,868 for dialysis and \$18,496 for transplantation (4). The total estimated cost for Medicare patients with ESRD in 1998 was \$12.04 billion, a sum that served 0.7% of the Medicare population but consumed approximately 5% of the annual Medicare budget (4). Continued growth in the number of patients with ESRD will also have an effect on the non-Medicare system of care. Treatment of patients with ESRD outside the Medicare system cost \$4.7 billion annually in 1999, and this amount will continue to increase, particularly because employer group health plan coverage for ESRD care was extended from 18 to 30 mo in the middle 1990s.

As the ESRD program enters this new century, continued growth in the number of patients and in program costs poses challenges for policy makers, health care providers, and financial planners. Unfortunately, few data are currently available on the projected ESRD patient population in the next 10 years. To assist in the planning of the ESRD health care delivery system in this new century, we modeled historical data from 1982 through 1997 and forecasted the American ESRD patient population to the year 2010.

Materials and Methods

Data on treated patients with ESRD in the United States, including new patients and long-term ESRD, dialysis, functioning transplant, and wait-listed patients, were obtained from United States Renal Data System (USRDS) annual data reports, as of December 31 of each year, for 1982 to 1997 (2,3). The SAS (5) "forecast" procedure, which includes extrapolative forecasting methods for time-series historical data, was used to forecast populations for each patient group to 2010.

We forecasted each variable independently by using the stepwise autoregressive method, which combines a time-trend regression with an autoregressive model. This statistical method analyzes the trend in historical patient numbers to provide estimates of future numbers and uses the current observation as a "regressed" value from previous observations in the same time series (6). We also used exponential smoothing and trending to produce a time-trend forecast, which allows more weight for more recent observations than for earlier ones.

We then plotted the historical and forecasted values, providing the lower and upper 95% confidence limits for the forecasted values (7). This graphic display provides a visual representation of the fit of the data and the estimated range for the 10-yr projection period. We also plotted the residuals (the differences of forecasted values from his-

---

Received January 16, 2001. Accepted June 4, 2001.

Correspondence to Dr. Jay L. Xue, United States Renal Data System, Minneapolis Medical Research Foundation, 914 South 8th Street, Suite D-206, Minneapolis, MN 55404. Phone: 612-337-8979; Fax: 612-347-5878; E-mail: jxue@usrds.org

1046-6673/1212-2753
Journal of the American Society of Nephrology

torical values) from the forecasting regression models, which allowed us to more precisely examine the accuracy of the forecasted values.

After the forecasted values were obtained, we calculated the simple average annual rate of increase in the numbers of new, long-term ESRD, dialysis, functioning transplant, and wait-listed patients, to provide a reference that does not require a detailed understanding of the exponential regression models. The rates are presented as average annual percentages, similar to those reported for interest rates, *i.e.*, rates for the present year are computed on the basis of the values for the previous year.

Results

Incidence counts were forecasted by using two different models. In model 1, we used the stepwise autoregressive method; in model 2, we added the quadratic trend to model 1. Figure 1, for example, illustrates the incidence forecasted using model 1. The dashed line indicates the historical data on incidence counts from 1982 to 1997, the solid line indicates the forecasted incidence counts, and the lines below and above the solid line from 1998 to 2010 indicate the lower and upper 95% confidence limits, respectively, for the forecast. Because all other forecasted variables appeared similar, we did not present them in Figure 1.

The forecasted numbers of new patients differed according to the models used. According to model 1, the average annual growth in the number of new patients with ESRD between 1998 and 2010 was forecasted to be approximately 4.1%, with the absolute numbers of new patients with ESRD being forecasted as 89,749 ± 5854 (95% confidence limit) in 2000, 109,280 ± 6790 in 2005, and 129,200 ± 7742 in 2010. Model 1 provided a conservative estimate of the growth in the number of new patients by forcing the regression model to pass through the last data point in 1997, giving recent data the most weight.

Incidence counts were also forecasted with a second model, which provided the best fit of the data and demonstrated a quadratic pattern for the trended time period. Modeling of the data with quadratic smoothing demonstrated an average annual rate of increase in the counts from 1998 to 2010 of 6.6%, a less conservative forecast than that of model 1. The numbers of new patients with ESRD forecasted with the second model were 98,953 ± 4093 in 2000, 133,086 ± 7836 in 2005, and 172,667 ± 13,499 in 2010.

Point prevalence ESRD counts were forecasted by using exponential smoothing with a quadratic trend (Table 1), a method similar to that used to forecast the incidence counts. This model was chosen because it provided the best fit of the data and minimized the residuals. From 1998 to 2010, the numbers of patients with long-term ESRD were projected to increase at an average annual growth rate of approximately 6.4%, whereas the total numbers of treated patients with ESRD were forecasted to be 372,407 ± 10,163 in 2000, 501,875 ± 12,458 in 2005, and 651,330 ± 15,874 in 2010.

The numbers of long-term dialysis, functioning transplant, and wait-listed patients were forecasted by using the stepwise autoregressive method with a quadratic trend (Table 1). These patient numbers increased in a quadratic pattern as well, with the average annual growth rates from 1998 to 2010 being approximately 7.1% for dialysis patients, 6.1% for patients with functioning transplants, and 8.2% for wait-listed patients. Medicare costs were also forecasted using this method and increased in a quadratic pattern, with an average annual growth

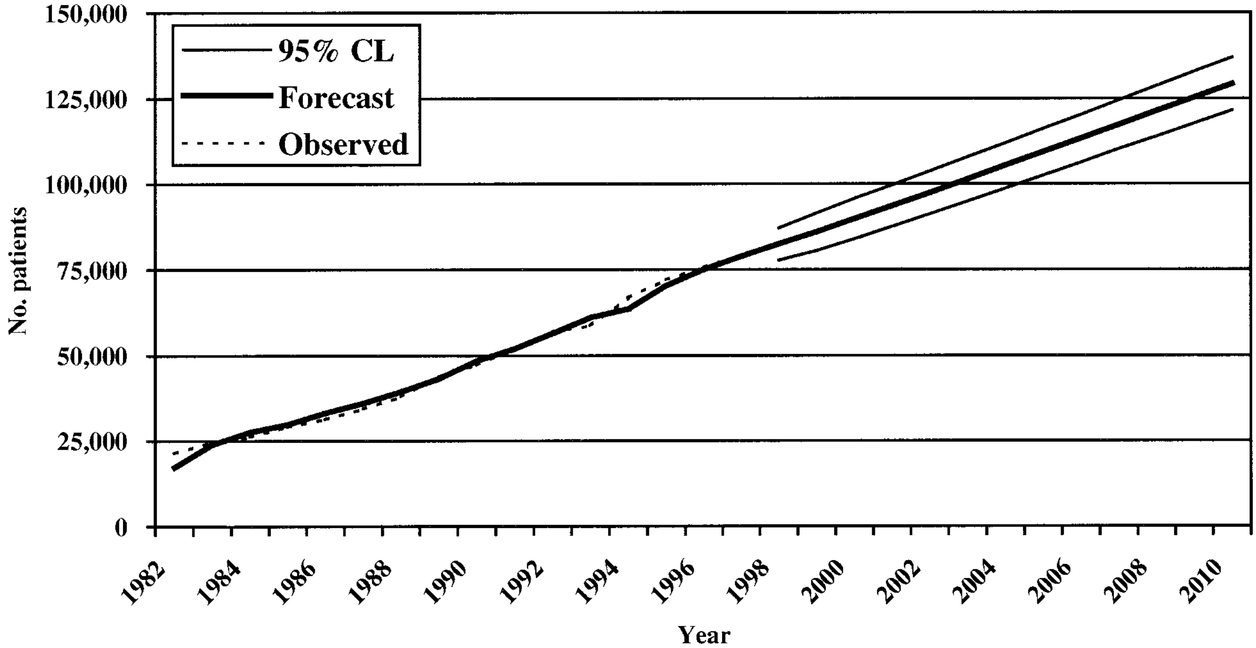

Figure 1. Forecasted incidence counts according to the stepwise autoregressive model (model 1). The dashed line indicates the observed incidence counts from 1982 to 1997, the solid line indicates the forecasted incidence counts, and the lines above and below the solid line from 1998 to 2010 indicate the upper and lower 95% confidence limits (CL), respectively, for the forecasted counts.

rate of approximately 7.7% to the year 2010 (Table 1). These analyses provided the best fit of the data, as evident in the goodness-of-fit statistical values in Table 2. The average forecasting errors for different ESRD patient groups ranged from −0.005 to 2344, representing proportional deviations from the observed data of −0.03 to 1.03%. The mean error for Medicare payments was −$6.01 million, *i.e.*, a −0.12% difference between the regressed and actual data. The variations in the predicted *versus* actual data, represented as R^2 values, demonstrated that 99.09% and 99.98% of the variation was explained by the models, and the correlation coefficients decreased to between 0.9955 and 0.9999 for models 1 and 2, respectively.

Discussion

Predictions of the growth of the ESRD population were previously reported for the United States (8,9) and Canada (10–12). Reports on the projected United States ESRD population, however, were not well documented, which limited our ability to compare the method used in this study with those used previously. In this study, we used the forecasting and time-series analysis approach, which has been widely used in the fields of process control, production, financial forecasting, and human biologic studies (6,13).

We used two different models to forecast incidence, because of the fluctuations in incidence counts recorded in USRDS annual data reports (3). These fluctuations, which created an overforecasting in 1993 and an underforecasting in 1994, relative to the observed values, had significant effects on the forecasting of future patient numbers. The fluctuations have been described in USRDS annual data reports as arising from an irreconcilable data problem, one imbedded in the Health Care Financing Administration data system and most likely representing under-reporting of patients in 1993 and over-reporting in 1994. The fluctuation in 1993 resulted in the largest absolute error (4135 patients) and percentage error (19.2%) in model 1 but yielded a more conservative estimate of the growth of the population through 2010. The actual numbers recorded in 1997 were lower than the forecasted incidence counts from model 2, suggesting that model 2 may have overforecasted these counts. This may have been the result of taking the best fit of the data, which yielded the lowest residuals and best R^2 values, compared with the model 1 method, which did not fit the data as well but provided more conservative estimates. We therefore preferred model 1 for the incidence forecast, although model 2 exhibited slightly better goodness-of-fit statistical values. Because the data for long-term ESRD, dialysis, functioning transplant, and wait-listed patients and for Medicare costs did not have the same large discontinuities in 1993 and 1994, we used only the model that provided the best fit of the data.

Markov models have been previously used to project the numbers of patients with ESRD (11). The time-trend and time-series processes we used in our analysis have similarities to Markov models. When a time-series model is used for the first-order autoregressive process, it is often called the Markov process (6), with “first-order” meaning that the observation at the present time depends solely on the immediately preceding observation. Key components in Markov modeling of the numbers of patients with ESRD include calculation of the probability of transition from one state to another state and the follow-up time (up to 5 yr in previous studies) (11,12,14–16). We used actual data for 16 yr, which may compromise some of the assumptions regarding the stability of the transitional probabilities with time. Our methods combined time-trend models and time-series methods, which capture long-term behavior, whereas autoregressive models capture short-term fluctuations. In addition, recent observations are weighted more heavily than older observations, thus improving the applicability of the estimates. We therefore think that our methods provide a

Table 1. Observed and forecasted values for selected years[a]

	1990	1997	2000	2005	2010
Incidence, model 1	48,359	78,804	89,749	109,280	129,200
	47,251	79,102	±5,854	±6,790	±7,742
Incidence, model 2	47,029	81,087	98,953	133,086	172,667
	47,251	79,102	±4,093	±7,836	±13,499
Prevalence	166,494	304,410	372,407	501,875	651,330
	170,025	304,083	±10,163	±12,458	±15,874
Dialysis	125,352	225,852	281,355	390,437	520,240
	124,918	221,596	±7,764	±14,865	±25,609
Functioning transplant	47,291	86,488	105,539	140,295	178,806
	47,339	86,371	±1,318	±2,524	±4,349
Waiting for transplant	16,989	35,765	46,687	68,722	95,550
	17,557	36,036	±1,661	±3,179	±5,478
Medicare cost ($, in millions)	5,206	10,892	14,208	20,551	28,292
	5,142	10,765	±521	±1,012	±1,743

[a] The top values for each variable are forecasted values. The bottom values for each variable in the 1990 and 1997 columns are observed values. The bottom values in the 2000, 2005, and 2010 columns are 95% confidence intervals for the forecasts.

Table 2. Goodness-of-fit statistical values

	Incidence		Prevalence	Dialysis	Functioning Transplant	Waiting for Transplant	Medicare Cost ($, in millions)
	Model 1	Model 2					
Mean error[a]	74	0.001	2344	−0.005	0.003	0.001	6
largest error (residual)	4135	1722	7760	3331	782	625	236
smallest error (residual)	−2365	−1985	−1750	−4256	−672	−851	−126
Mean percent error[b]	0.25	−0.03	1.03	−0.03	0.06	−0.11	−0.12
largest percent error	19.23	4.38	2.90	3.56	6.37	5.63	4.84
smallest percent error	−5.76	−3.83	−2.18	−3.60	−3.35	−6.16	−2.99
R^2	0.9909	0.9963	0.9973	0.9983	0.9998	0.9974	0.9985
Correlation coefficient[c]	0.9955	0.9981	0.9995	0.9991	0.9999	0.9987	0.9993

[a] The mean error indicates an average difference (1982 to 1997) of the forecasted values from the observed values. Largest and smallest errors indicate one of the 16 yr (1982 to 1997) that exhibited the largest or smallest deviation of the forecasted value from the observed value. A positive sign indicates overforecasting, and a negative sign indicates underforecasting.

[b] The mean percent error reflects a proportional deviation of the mean error. Largest and smallest percent errors reflect proportional deviations of the largest and smallest errors, respectively.

[c] The correlation coefficient indicates the correlation between the observed values and the one-step-ahead forecasted values.

reasonable compromise between a complex model, such as the Markov process, and the time-series approach.

The forecasted point prevalence total ESRD counts demonstrated an exponential growth trend with a quadratic pattern, whereas the forecasted incidence counts demonstrated a pattern of stepwise autoregressive growth that was more linear in nature. This difference is most likely attributable to improved survival rates for dialysis and transplantation; survival of new patients, for instance, has a direct effect on the long-term ESRD population, because the loss of patients from the pool is reduced. Recent improvements in the survival rates for both dialysis and transplant patients seem to have created a separation in the trends. Incidence counts may be increasing with a more linear trend but the prevalent population continues to grow with a more exponential trend, because the death rate is lower and patients are accumulated at a rate that overcomes the reduced influx of new patients. Incidence counts increased by 20,478 from 1993 to 1997 (a 4.5% increase), whereas prevalence counts increased by 80,430 (6.1%) (3). These differences led us to use different models to forecast the growth of the new and long-term ESRD populations.

The number of patients with functioning transplants in 2010 was forecasted to be 178,806, a population 2.1 times greater than that in 1997 (86,371 patients). This rate of increase was lower than that in the previous 13-yr period (1984 to 1997), during which the population increased 4.6-fold, from 18,916 patients in 1984 to 86,371 patients in 1997. The main source of the increase seems to be improved graft and patient survival rates. Although the limited availability of organs has reduced the number of new transplants, improved organ and patient survival rates have contributed to the growth in the functioning transplant population (4).

The 95% confidence limits provide precision for the estimates, on the basis of trends for actual data for 1982 to 1997. These limits increase in width as the forecast lead time increases, suggesting that the reliability of the forecasted values decreases as the time from the actual data increases. These forecasts should be repeated on a regular basis, to determine whether changes in the trends, which may not be readily apparent in the most recent time periods, can be identified early.

Because these forecasts are based on historical data, they are by nature vulnerable to inaccuracies, which may undermine the predictive value of any model used. For example, the number of new patients with ESRD may increase because of factors such as earlier dialysis start times. The *USRDS 2000 Annual Data Report* noted that estimated creatinine clearances increased 12.5% between 1995 and 1998, suggesting that patients were beginning dialysis with higher estimated creatinine clearance values; this might lead to higher incidence rates, compared with those indicated by the historical patterns (4).

The changing demographic characteristics of the general population may also affect the numbers of new patients with ESRD, particularly because minority populations are increasing as a percentage of the total United States population. These minority populations exhibit higher rates of ESRD, particularly because of diabetes mellitus (4). Two-thirds of ESRD patients of Hispanic Mexican origin, for example, have a primary diagnosis of diabetes mellitus (4). The growth in this population may significantly affect the incidence rates of ESRD, particularly related to diabetes mellitus. There has been a major shift in the primary cause of renal failure among the black ESRD population. Diabetes mellitus has overtaken hypertension as the most frequent cause of ESRD among the black population (4), and this population may contribute more new patients in the future, because the incidence rates of ESRD for this population are four times greater than those for the white population. The primary cause of these higher rates of diabetes mellitus seems to be the increasing weight of the general population (17), as well as the ESRD population. The mean weight of new patients with ESRD increased 3% between 1995 and 1997, supporting the trend of increasing weight noted for the general population (4). Although increased weights are an indication of diabetic risk for the general population, they seem to be associated with a reduced risk of death among dialysis patients (18,19); this trend would increase the survival rate for long-term ESRD patients and thus the growth of this population as well.

More effective prevention, intervention, and early detection programs for renal diseases are likely to reduce ESRD incidence counts, however. Interventions such as the increased use of angiotensin-converting enzyme inhibitors and angiotensin receptor type 2 antagonists to slow the rate of decline in renal function, for instance, may significantly reduce the incidence rate (20–23). For the diabetic population, improved glucose control with the use of thiazolidenediones and newer lipid treatments not only may reduce the rate of renal loss but also may improve glycemic control and reduce lipid levels, which would lower the mortality rate for diabetic patients. Antismoking initiatives may also help slow the progression of chronic kidney disease, because smoking seems to be a risk factor for the development of microalbuminuria, which is itself a risk factor for the development of ESRD (24).

Changes in ESRD treatment may also contribute to the growth of individual therapies, such as renal transplantation. Xenotransplantation of transgenic porcine kidney xenografts was recently successfully performed with nonhuman primates (16). If this process can be adapted to human patients, then the transplant population could increase dramatically.

The Medicare expenditures forecasted in this study were based on historical data from 1982 to 1997. It is likely that the actual expenses will be different if the ESRD population changes significantly from that patterned during the past 16 yr. Changes in governmental payment policies would also have an effect on the number of patients with ESRD treated through the Medicare system. Alterations in the length of time that employer group health plans cover patients with ESRD who are <65 yr of age (now changed from 18 to 30 mo) could slow the rate of growth of Medicare costs; the total costs, however, would still be a function of the overall Medicare and non-Medicare ESRD populations.

Although future ESRD populations may not grow as forecasted here, our results are still useful for policy makers, health care providers, and financial planners and present important issues related to health care access. It seems that, if the current trends continue, the ESRD program will cost Medicare $28.3 billion by 2010, which represents a more than twofold increase over current expenditures. Pressures on provider systems will also continue, with increased demands for nephrologists, nurses, technicians, transplant programs, and organ procurement systems. The ratio of patients with ESRD to nephrologists was between 50.0:1 and 54.7:1 in 1994 to 1999 (3,25,26). If projections of the numbers of nephrologists (27) and patients with ESRD are accurate, then this ratio will be 80.4:1 in 2010. Because nephrologists are typically the primary care providers for dialysis patients, these possibilities need to be given careful consideration.

In summary, all of the modeled projections suggest that the numbers of new and total patients with ESRD, dialysis patients, transplant patients, and wait-listed patients in the United States will continue to increase to 2010. The projected average annual growth rates for the ESRD population are 4.1% for new patients, 6.4% for overall ESRD patients, 7.1% for long-term dialysis patients, 6.1% for patients with functioning transplants, and 8.2% for patients on waiting lists for transplants. The numbers of patients with ESRD anticipated by 2010 are 129,200 new patients, 651,330 patients with long-term ESRD overall, 520,240 patients undergoing long-term dialysis, 178,806 patients with functioning transplants, and 95,550 patients on waiting lists. Appropriate planning for the care of this vulnerable population must be carefully considered.

Acknowledgments

We thank Tom Arnold, Mike Hadad, and Roger Milam from the Health Care Financing Administration for their assistance with the HCFA data. We also thank Beth Forrest for her help in manuscript preparation and regulatory assistance. Data set construction and data manipulation was provided by Shu-Cheng Chen, Roger Johnson, and C. Daniel Sheets. This project was funded in whole or in part with federal funds from the National Institute of Diabetes and Digestive and Kidney Diseases, National Institutes of Health (Contract N01-DK9-2343).

References

1. Social Security Administration: *Social Security: Your Number*, Social Security Administration, 1996
2. United States Renal Data System: *USRDS 1994 Annual Data Report*, Bethesda, MD, National Institutes of Health, National Institute of Diabetes and Digestive and Kidney Diseases, 1994
3. United States Renal Data System: *USRDS 1999 Annual Data Report*, Bethesda, MD, National Institutes of Health, National Institute of Diabetes and Digestive and Kidney Diseases, 1999
4. United States Renal Data System: *USRDS 2000 Annual Data Report*, Bethesda, MD, National Institutes of Health, National Institute of Diabetes and Digestive and Kidney Diseases, 2000
5. SAS: *SAS/ETS User's Guide*, Cary, NC, SAS, 1993
6. Montgomery DC, Johnson LA, Gardiner JS: *Forecasting and Time Series Analysis*, 2nd Ed., New York, McGraw-Hill, 1990
7. SAS: *SAS/GRAPH Software*, Cary, NC, SAS, 1990
8. Port FK: Worldwide demographics and future trends in end-stage renal disease. *Kidney Int* 41[Suppl]: S4–S7, 1993
9. Port FK: End-stage renal disease: Magnitude of the problem, prognosis of future trends and possible solutions. *Kidney Int* 50[Suppl]: S3–S6, 1995
10. Desmeules M, Schaubel D, Fenton S, Mao Y: New and prevalent patients with end-stage renal disease in Canada: A portrait of the year 2000. *ASAIO J* 41: 230–233, 1995
11. Schaubel DE, Morrison HI, Desmeules M, Parsons DA, Fenton SS: End-stage renal disease projections for Canada to 2005 using Poisson and Markov models. *Int J Epidemiol* 27: 274–281, 1998
12. Schaubel DE, Morrison HI, Desmeules M, Parsons DA, Fenton SS: End-stage renal disease in Canada: Prevalence projections to 2005. *Can Med Assoc J* 160: 1557–1563, 1999
13. Matsuda S: Geographic differences in seasonality of preterm births in Japan. *Hum Biol* 70: 919–935, 1998
14. Farrow SC, Fisher DJ, Johnson DB: Statistical approach to planning an integrated hemodialysis/transplantation program. *Br Med J* 2: 671–676, 1971

15. Farrow SC, Fisher DJ, Johnson DB: Dialysis and transplantation: The national picture over the next five years. *Br Med J* 3: 686–690, 1972
16. Davies R, Johnson D, Farrow S: Planning patient care with a Markov model. *Oper Res Q* 26: 599–607, 1975
17. Visscher TL, Seidell JC: The public health impact of obesity. *Annu Rev Public Health* 22: 355–375, 2001
18. Fleischmann EH, Bower JD, Salahudeen AK: Risk factor paradox in hemodialysis: Better nutrition as a partial explanation. *ASAIO J* 47: 74–81, 2001
19. Kaizu Y, Tsunega Y, Yoneyama T, Sakao T, Hibi I, Miyaji K, Kumagai H: Overweight as another nutritional risk factor for the long-term survival of non-diabetic hemodialysis patients. *Clin Nephrol* 50: 44–50, 1998
20. Hollenberg NK, Raij L: Angiotensin-converting enzyme inhibition and renal protection: An assessment of implications for therapy. *Arch Intern Med* 153: 2426–2435, 1993
21. Materson BJ, Preston RA: Prevention of diabetic nephropathy. *Hosp Pract (Off)* 32: 129–140, 1997
22. Mora-Macia J, Cases A, Calero F, Barcelo P: Effect of angiotensin II receptor blockade on renal disease progression in patients with non-diabetic chronic renal failure. *Nephrol Dial Transplant* 16[Suppl 1]: 82–84, 2001
23. Eliahou H, Avinoach I, Shahmurov M, Ben David A, Shahar C, Matas Z, Zimlichman R: Renoprotective effect of angiotensin II receptor antagonists in experimental chronic renal failure. *Am J Nephrol* 21: 78–83, 2001
24. Grimm RH Jr, Svendsen KH, Kasiske B, Keane WF, Wahi MM: Proteinuria is a risk factor for mortality over 10 years of follow-up: MRFIT Research Group: Multiple Risk Factor Intervention Trial. *Kidney Int Suppl* 63: S10–S14, 1997
25. American Board of Medical Specialties: *The Official American Board of Medical Specialties (ABMS) Directory of Board Certified Medical Specialists*, Evanston, IL, American Board of Medical Specialties, Research and Education Foundation, 1995
26. American Board of Medical Specialties: *The Official American Board of Medical Specialties (ABMS) Directory of Board Certified Medical Specialists*, Evanston, IL, American Board of Medical Specialties, Research and Education Foundation, 2000
27. Kletke PR, Marder WD: The supply of renal physicians: An analysis of data from the American Medical Association Physician Masterfile. *Am J Kidney Dis* 18: 384–391, 1991